THE ITERATIVE ENSEMBLE KALMAN SMOOTHER: THE BEST OF BOTH WORLDS?

– talk –

MARC BOCQUET

Data assimilation seeks a mathematically optimal compromise between outcomes of a numerical model that simulates a physical system and observations of that system. It has been successfully used for twenty years in operational meteorology to perform the best forecast, and is now being used or tested in many geoscience fields. Two main classes of methods have taken the lead.

Firstly, *4D-Var* is a method from optimal control theory that finds the most likely initial condition of the system at the beginning of a temporal window. 4D-Var is a variational scheme and minimises on the initial condition a cost function that represents the misfit of the model with the observations and a previous forecast. As a nonlinear smoother it is a powerful method. But it requires the adjoint of the model, which is a formidable technical task for large geophysical models. It is also difficult to extract the uncertainty attached to the optimal initial condition and to pass it to the subsequent analysis.

As an alternative method, the *ensemble Kalman filter* (EnKF) easily propagates the uncertainty with the use of an ensemble of model trajectories. As a filter it does not require the use of the model adjoint. However, the use of a necessarily limited number of ensemble members leads to sampling errors that call for the use of *ad hoc* techniques, namely inflation and localisation, to make the method practical.

We have recently introduced the *iterative ensemble Kalman smoother* (IEnKS) that has the potential of getting the best of both methods. It is not an *hybrid* method as it does not seek to combine both methods. Like 4D-Var, as a nonlinear smoother, it solves for an underlying variational problem, but without the use of the tangent/adjoint model. Like the EnKF, it is a flow-dependent method and propagates the uncertainty. We will show on meteorological toy-models that the method systematically outperforms 4D-Var, the EnKF and even a standard ensemble Kalman smoother. However, as an ensemble method, it is still plagued by sampling errors and the implementation of inflation and localisation still needs investigating in this context.

(1) Université Paris-Est, CEREA joint laboratory École des Ponts ParisTech and EdF R&D, France., (2) INRIA, Paris Rocquencourt research center, France.

E-mail address: bocquet@cerea.enpc.fr